A measured section of the Palæozoic Rocks of Central Pennsylvania, from the top of the Allegheny River Coal Series, down to the Trenton Limestone in the Lower, or Cambro-Silurian System.

By Charles A. Ashburner,

Asst. 2d Geol. Surv. Pa.

(*Read before the American Philosophical Society, February* 16, 1877.)

The following long section of the Palæozoic strata of Huntingdon County, Pennsylvania, is the result of an instrumental study of a district bounded on the west by Broad Top Mountain ; on the north by the East Broad Top Railroad ; on the east by Blacklog Valley ; on the south by Sideling Hill Creek.

Two vertical sections were constructed along cross section lines, in a north-west direction, from the Trenton limestone of Blacklog Valley to the Broad Top coal basin, a number of other shorter sections were made along selected portions of the district between the two longer lines.

The results of the measurements made on these several lines of survey, sufficiently near together to check one another, are given in the following pages.

The whole height of the vertical section, from the top of the Mahoning sandstone in the Coal Measures down to the bottom of the Trenton limestone, is eighteen thousand three hundred and ninety-four feet (18,394′), distributed as follows :

Carboniferous Strata*.....at least.	3,777′	
Devonian Strata.....	7,975′	
Oriskany Sandstone†.....	58′	=18,394′‡
Upper and Middle Silurian.....	4,214′	
Lower or Cambro-Silurian.....at least.	2,370′	

This section would therefore represent the record of a shaft or bore hole 3½ miles deep, sunk from the surface of the land of the Broad Top Coal Basin at Broad Top City.

Carboniferous.

No. XIII.

Alleghany River (*Lower Productive*) *Coal Measures*. ..... 264′

267. Mahoning Sandstone. A white conglomerate sandstone, containing a softer shaly mass and a coal bed..... 90′

* The base of the carboniferous being in dispute, the term is here made to include the Pocono, Vespertine, or Upper Catskill, X, for reasons evident in the section.

† Geologists may include the Oriskany in the Devonian or in the Silurian as they see proper.

‡ To get this total the measurements of the rocks *above* the Clinton lower olive shale at Saltillo are added to those of the rocks *below* that horizon at Orbisonia.

266. Sandstone and shale, *containing a small bed of coal*, in black slate and shale, a short distance below the bottom of the Mahoning Sandstone, probably representing Coal E, Upper Freeport. Lower part, directly above Coal D, hard, rather massive black slate. ..... 45′

265. Coal bed D, (top bench mine C).....2′1″
264. Black fissile slate containing seams of coal varying in thickness from $\frac{1}{4}$ to $\frac{1}{8}$ inch.....0′4″
263. Coal bed D, (middle bench).....0′2″
262. Slate containing a stratum of sandstone about the centre .....2′1″
261. Coal bed D, (bottom bench). Fireclay floor of the mines unmeasured.....3′1″ } 7′9″

260. Sandstone and shale; black slate lower part..... 45∓′

259. Coal bed C, (top bench mine B).....1′6″
258. Hard grayish-black slate, (varying thickness)...0′4″
257. Coal bed C, (bottom bench). Fireclay floor of the mines unmeasured.....2′0″ } 3′10″

256. Sandstone, shale and slate..... 30′

255. Coal bed B, (top bench mine A). .....1′ 6″
254. Rock and fireclay.....1′ 4″ } 4′8″
253. Coal bed B, (bottom bench).....1′10″

252. Sandstone and shale..... 35′

251. Coal bed *A*, underlaid by a carbonaceous black fireclay, commonly called black gravel..... 2′

No. XII

Pottsville (*Seral*) *Conglomerate* (*Millstone Grit.*)..... 280′

Upper Member. *Piedmont Sandstone.*

250. Upper member consisting of three parts, upper white and reddish white and gray flaggy sandstone and conglomerate; in the middle part the conglomerate predominates, the pebbles are larger but irregularly distributed, the strata exhibiting false bedding to a marked degree; while the lower part is composed principally of thinly bedded and conglomeratic sandstone..... 160′

Middle member (*Kanawha River Coal Series*).

249. Sandstone and shale, " " ..... 14′
248. Coal (Fireclay floor unmeasured)..... 2′
247. Less massive gray sandstone exhibiting false bedding.. 17′
246. Dark gray and black slate and slaty sandstone..... 7′

Lower member (*Conglomerate proper.*)

245. Hard massive gray sandstone, strata fractured in a perpendicular and also oblique direction to the bedding, surfaces

stained and coated with ferric oxide, containing impressions of calamites, lepidodendra leaves and sigillaria..... 10′

244. Upper part consists of a hard massive gray and white sandstone and conglomerate, the latter predominating toward the central part where the pebbles are large ; while in the lower part there is less conglomerate, the sandstone becoming dark gray and flaggy, containing micaceous specks..... 70′

No. XI.

Mauch Chunk (*Umbral*) *Red Shale*..... 1100′

Upper Member.

243. Brown silicious and shaly hematite, varying thickness.
242. Yellow argillaceous sand shale 5 ± feet.....
241. Yellow and greenish-yellow flaggy sandstone with slight alternations of green argillaceous shale 20 ± feet.... } 150′
240. Red and gray sandstones, and shales, rather flaggy and argillaceous .....

[At the west end of Wray's Hill Tunnel.]

239. Very soft bright red shale..... 59′
238. Hard grayish-red sandstone showing false bedding... 41′
237. Red sandstone containing white calcareous seams along planes of false bedding..... 48′
236. Softer red sandstone..... 28′
235. Dark grayish-red sandstone, much harder and exhibiting false bedding and perpendicular fracture..... ..... 14′
234. Friable soft bright red sandstone and shale..... 93′

[At the east end of Wray's Hill Tunnel.]

233. Partly concealed. Probably composed of red and gray sandstone with alternations of red and gray shales and flags.. 300′
232. Probably red shales and sandstone..... 177′

Middle member (*Mountain Limestone.*)

231. Red shaly limestone ..... 3 ±′
230. Red shale very argillaceous..... 10 ∓′
229. Soft argillaceous red shale..... 5′
228. Massive silicious red limestone (easily weathered) containing *Terabratula Rœmingeri, Grammysia, Strophodonta, Rhynchonella*..... 2′6″
227. Very soft red shale..... 2′
226. Red and gray mottled, calcareous shale (concretionary) contains *Centronella* ..... 3′
225. Red calcareous shale and limestone..... 9′
224. Variegated red and gray massive limestone..... 1′
223. Gray massive limestone..... 3′
222. Red shale..... 6′
221. Greenish-gray argillaceous limestone..... 4′

Lower member.

220. Concealed	3′
219. Partly concealed. Probably composed of massive red silicious sandstone and shale with alternations of gray sandstone and flags	114′
218. Coarse grained greenish-gray sandstone overlaid by red shale	3′
217. Heavy argillaceous gray sand shale, conchoidal fracture containing streaks of hematite and manganese	7′
216. Reddish-gray, sandy slate colored with ferric oxide	3′
215. Very hard, flinty greenish-gray, massive sandstone	7′
214. Alternating brittle green and red shale	2′
213. Hard, dark-gray sandy slate	2′

No. X.

Pocono (*Vespertine*) *Gray Sandstone* ..... 2123′

Upper member.

212. Partly concealed. Composed for the most part of hard, coarse grained, massive, brownish-gray and gray sandstone, alternating with thinly bedded and flaggy sandstone, and shale of the same color. Near the top a few beds of red shale and sandstone	580′

[At the west end of Sideling Hill tunnel.]

211. Massive gray sandstone surfaces coated with ferric oxide	8′
210. Alternating massive gray and greenish-gray sandstone containing a twelve inch seam of black slate showing impressions of minute plants	22′

Middle member, upper part.
(*New River Coal Series*).

209. Massive gray sandstone containing thin partings of coal.	29′
208. Gray argillaceous sand	5″
207. Coal (seam No. 19)	2½″
206. Soft greenish-gray micaceous shale	1′3″
205. Light gray, massive sandstone containing thin plates of coal and micaceous specks	56′
204. Sandstone containing thin partings of coal	1′
203. Soft, loose sandstone containing seams of coal, running irregularly through the mass, amounting in all to about 5 inches	6′
202. Massive sandstone containing in its lower part plates of coal	12′
201. Poor, bony coal (Seam No. 18)	2″
200. Sandstone	1′6″
199. Argillaceous sand	¼″
198. Coal (Seam No. 17), maximum thickness 9 inches	3″

197. Argillaceous sand containing plates of coal..... 4″
196. Gray sandstone containing between the strata a great deal of loose sand..... 15′
195. Gray sandstone containing nodules of pyrites and plates of coal in the upper portion of the mass..... 26′
194. Coal very much broken up. (Seam No. 16)..... 1″
193. Sandstone containing nodules of iron pyrites..... 2′6″
192. Coal (Seam No. 15); brilliant lustre, rhombohedral fracture, resembling bituminous coal ..... 1″
191. Sandy fireclay..... 6″
190. Coal (Seam No. 14)..... 1″
189. Sandstone with thin partings of coal in the lower portion..... 4′
188. Sandstone..... 9′
187. Fireclay..... 1″
186. Shaly sandstone..... 34′
185. Coal (Seam No. 13)..... 1″
184. Alternating shaly and massive, gray sandstone..... 6′
183. Poor bony coal (Seam No. 12)..... 3″
182. Shaly sandstone..... 6′
181. Coal (Seam No. 11); very much broken up and associated with red sand..... 1″
180. Shaly sandstone..... 4′
179. Coal (Seam No. 10) maximum thickness 6 inches..... 3″
178. Shaly sandstone..... 2′
177. Coal (Seam No. 9) ..... 1″
176. Shaly sandstone..... 1′
175. Coal with sandstone above and below (Seam No. 8) 1″
174. Gray sandstone..... 36′
173. Steel gray shale of a greasy lustre..... 8″
172. Coal (Seam No. 7)..... 1″
171. Fire clay..... 1″
170. Sandstone..... 5′
169. Coal (Seam No. 6)..... 1″
168. Sandstone ..... 10″
167. Coal (Seam No. 5) resembling very much specimens from Montgomery County, Virginia..... 2″
166. Soft sandstone..... 5″
165. Coal (Seam No. 4)..... 2″
164. Sandstone containing loose brown, argillaceous sand.. 14′
163. Loose sand shale, surfaces coated with acicular crystals of sulphate of alumina formed by the decomposition of pyrites..... 3′
162. Coal; very much broken up by false bedding and containing a great deal of iron pyrites (Seam No. 3)..... 2″
161. Massive, gray sandstone having a rhombohedral fracture and containing specks of slate and ferruginous matter.... 28′

160. Coal (Seam No. 2); very much broken up by false bedding..... 1″
159. Soft, gray, shaly sandstone exhibiting false bedding.. 5′
158. Poor bony coal (Seam No. 1)..... 1″

Middle member. Lower part.

157. Soft, black shale containing plates of coal and impressions of minute plants, surfaces stained with ferric oxide; alternating with a fine grained conglomerate containing micaceous specks..... 25′
156. Yellowish-gray, argillaceous shale containing thin plates of coal. Surfaces showing "slicken sides."..... 26′
155. Sandstone..... 9′
154. Black, carbonaceous slate enclosed in hard massive sandstone..... 2″
153. Hard, massive, gray sandstone..... 17′
152. Hard, conglomeritic, light gray sandstone containing a few alternations of black slate..... 51′
151. Hard, massive sandstone alternating with gray slaty micaceous sandstone..... 45′
150. Soft, gray shale..... 1′
149. Alternating dark gray, flaggy and slaty sandstone containing micaceous scales..... 33′
148. Dark gray, argillaceous shale with talcy lustre..... 39′
147. Dark greenish-gray shale, with talcy lustre, containing acicular crystals of sulphate of alumina formed by the decomposition of pyrites..... 10″
146. Soft, black slate..... 3″
145. Massive, gray sandstone..... 3′
144. Soft, gray, argillaceous shale..... 5′6″
143. Massive, hard gray sandstone..... 25′
142. Fine grained, light gray conglomerate alternating with thin strata of black micaceous sandstone..... 13′
141. Fine grained, dark gray, argillaceous shale alternating with a hard, gray sandstone interstratified with a black micaceous sandstone..... 26′
140. Massive, flinty gray sandstone alternating with yellowish-gray sandstone showing false bedding..... 17′
139. Soft, gray shale..... 1′3″
138. Hard, gray sandstone..... 1′6″
137. Soft, gray shale..... 1′6″
136. Soft, yellowish gray shale of a talcy lustre..... 1′6″
135. Very hard, massive bluish-gray sandstone, with occasional seams of a lead-colored clay..... 4′
134. Hard, massive gray sandstone..... 13′
133. Gray slaty sandstone..... 10″
132. Carbonaceous shale..... 5″

131. Gray shale..... 3″
130. Black coal slate..... 2″
129. Gray sand shale..... 3′4″
128. Black slate..... 4″
127. Hard, massive gray sandstone alternating with yellowish gray, argillaceous sand shales..... 15′

Lower Member.

126. Dark bluish-gray slaty sandstone alternating with a shale of close texture..... 22′
125. Alternating gray, green and yellow shale..... 25′
124. Green shale containing *Cypricardina* and *Orthis*. ... 5′

[At the East end of Sideling Hill Tunnel.]

123. Partly concealed. Alternating as above but softer.... 25′
122. Hard, coarse-grained reddish-gray sandstone alternating with soft, yellow sandy shale..... 165′
121. Coarse-grained yellow sandstone. Surfaces stained with iron, alternating with grayish-brown sandstone ..... 12′
120. Alternating yellow, gray and green shaly sandstone.. 44′
119. Soft yellow, sandy shale interstratified with a gray flaggy sandstone, alternating with a brown sandstone containing micaceous specks..... 50′
118. Flaggy olive sandstone alternating with a greenish-gray sandstone containing iron concretions. Partly concealed..... 42′
117. Partly concealed. Soft green and olive sandstone alternating with soft, yellow, flaggy and hard, massive gray sandstone containing ferruginous specks and having a distinct rhombohedral fracture..... 440′

Devonian.

No IX.

Catskill (*Ponent*) *Red Sandstone*..... 2680′

116. Concealed. Probably composed of red shales and sandstone alternating with white and gray sandstones.....175′
115. Greenish-gray, slaty sandstone containing micaceous specks alternating with soft, bright red shale..... 100′
114. Massive, coarse-grained, reddish-gray sandstone alternating with red shale and sandstone..... 125′
113. Very silicious brown hematite, thickness undetermined, but variable..... ——
112. Partly concealed. Consisting for the most part of red flaggy sandstone and shale alternating with massive yellow, gray and white shaly sandstone.....1520′
111. Red, sandy and argillaceous shale; lower part contain-

ing fucoid stems and showing a fine exhibition of ripple marks..... 270′

110. Red, massive sandstone and shale with slight alternations of green sandy shale and massive brown sandstone, particularly toward the lower part..... 140′

109. Red shale and sandstone alternating with gray shale and massive gray sandstone; containing small deposits of coal. 290′

108. Light yellow, sandy shale alternating with friable red shale; surfaces stained with bituminous matter. Lower part brownish-gray sandstone containing micaceous specks..... 60′

Transition Strata between IX and VIII..... 90′

107. Yellowish-white, argillaceous sand shale lower part containing lepidodendra and calamites..... 8′

106. Red sandstone and shale, containing ripple marks, with slight alternations of green shale..... 18′

105. Alternating olive-green sandstone and shale, lower part of a darker green color..... 10′

104. Greenish-gray sandstone and shale; upper 10 feet containing quartz crystals; lower part fossiliferous..... 15′

103. Alternating red sandstone and shale..... 25′

102. Green fissile shale..... 1′

101. "Larry's Cr. ore bed," ranging from 4 inches to 1 foot thick, containing *Spirifer disjuncta* and *Rhynchonella*..... 8″

100. Green fissile shale containing two sandstone strata, 2 inches thick, upper surfaces showing ripple marks and under surfaces containing impressions of fucoid stems..... 3′

99. Fossiliferous, brownish-gray sandstone containing *Spirifer disjuncta*, &c..... 1′

98. Dirty white sand shale containing plant impressions.... 3″

97. Yellowish-red sandstone..... 5′

96. Red shale, easily weathered, containing occasional seams of sandstone and green shale a few inches thick..... 3′ +

No. VIII.

Chemung (Vergent) Shales..... 1860′

95. Partly concealed. Consisting, for the most part, of olive and brown argillaceous sandstone and shale, containing alternations of red fissile shale. Readily weathered into clay.... 245′

94. Massive dark-gray sandstone containing ferruginous specks alternating with reddish-gray, flaggy sandstone..... 15′

93. Upper part fossiliferous greenish gray sandstone; lower part alternating soft red and light green sandy shale..... 100′

92. Massive brown sandstone. Surfaces stained with iron and coated with minute quartz crystals, alternating with light red shale, showing impressions of fucoids..... 70′

91. Red, brown and gray sandstone. The lower part is composed principally of red and olive sand shale containing micaceous specks; surfaces of the olive shale very much stained with iron..... 140′

90. Partly concealed. Consisting for the most part of hard, massive, gray and brown sandstone, containing micaceous specks, alternating with softer shaly strata..... 500′

89. Partly concealed. Composed principally of massive, gray and brown sandstone, containing yellow and red specks, alternating with softer sandstone and shale; the softer strata predominating more than in No. 90, being marked by sharp narrow ravines running parallel with the strike..... 490′

88. Brown, green and gray massive and flaggy sandstone; surfaces very much stained with iron. ..... 80′

87. Partly concealed. Consisting for the most part of red and olive shale and sandstone; former predominating..... 100′

86. Massive reddish-brown sandstone containing micaceous specks..... 10′

85. Massive reddish-brown sandstone, containing micaceous specks, and shale alternating with brown argillaceous sandstone containing crinoid stems..... 110′

Portage (Verjent) Flags..... 1450′

84. Partly concealed. Consisting for the most part of hard, massive brown and gray sandstone with alternating strata, from 10′ to 30′ thick, of soft olive and gray shale, marked in some cases by sharp narrow ravines running parallel to the strike..... 500′

83. Massive brown sandstone, containing iron specks, alternating with shale..... 40′±

82. Light fawn colored, argillaceous shale alternating with greenish yellow, flaggy sandstone; surfaces coated with minute quartz crystals..... 70′

81. Partly concealed. Composed principally of yellow, green and light olive shale alternating with occasional seams of brown and gray sandstone..... 140′

80. Light fawn colored, yellow and green argillaceous shale alternating with soft olive brown and green flaggy sandstone; latter containing yellow and red specks and surfaces stained with iron..... 100′

79. Light olive shale with yellow and red stains, lower part very fissile..... 80′

78. Yellow shale containing a few alternating seams of sandstone..... 80′

77. Dark olive and yellow argillaceous shale..... 120′

76. Light olive shale containing alternations of thinly laminated sandstone strata, from 1 to 2 inches thick..... 100′

75. Same in character as No. 76, but with the sandstone predominating..... 60′

74. Dark olive shale containing seams of shaly sandstone, stained bright red with ferruginous matter. ..... 50′

73. Olive, red and yellow shale..... 10′

72. Gray sandstone with a few alternating beds of olive shale. 35′

71. Fine grained, greenish-gray sandstone, in seams from 4 to 6 inches thick, alternating with fine-grained, olive fissile slate..... 65′

Genesee (Cadent Upper) Slate..... 325′

70. Partly concealed. Olive slaty and shaly sandstone alternating with brownish gray, flaggy sandstone and a few beds of olive shale..... 100′

69. Light olive and greenish-gray argillaceous shale and slate..... 75′

68. Partly concealed. Probably same in character as No. 69..... 100′

67. Dark olive, fissile slate with occasional seams of a bright brown-colored sandstone, 2 to 4 inches thick..... 50′

Hamilton (Cadent) Shales..... 635′

66. Partly concealed. Consisting for the most part of gray sandstone flags and shales containing fossils as in No. 65, but not as abundant..... 250′

65. Upper part, hard, massive greenish-gray and flaggy olive sandstone, lower part light, olive, slaty sandstone. Surfaces very much stained with iron. Contains: *Aviculopecten princeps, Chonetes mucronatus* and *coronata, Grammysia, Spirifer granulifera* and *mucronatus,* and *Tentaculites. Algæ* more particularly Spirophyton *caudagalli*..... 85′

64. Partly concealed. Consisting for the most part of massive, gray and flaggy sandstone alternating with beds of thinly laminated, fissile shale (fossiliferous)..... 200′

63. Thin, gray, calcareous, flaggy sandstone, and seams of greenish-gray, fragile sandstone alternating with gray and dark olive shale..... 100′

Marcellus (Cadent Lower) Black Slate..... 875′

62. Partly concealed. Composed principally of gray and brown shale alternating with flaggy and slightly calcareous sandstone..... 200′

61. Argillaceous gray, olive and brown shale very much stained with iron and bituminous matter..... 200′

60. Partly concealed. Consisting for the most part of brown, gray and black argillaceous shale with occasional seams of sandstone..... 171′

59. Gray, shaly, argillaceous limestone alternating with greenish-gray lime-shale (local deposit?)..... 20′
58. Black fissile slate and shale, surfaces very much stained with iron and coated with bituminous matter..... 100′
57. Black slate and brown shale, surfaces stained with iron and coated with bituminous matter; the shale in the lower part directly above the iron ore bed is very argillaceous..... 180′
56. Marcellus iron ore bed, varying thickness..... 4′

Upper Helderberg (Post Meridian) Limestone ..... 60′

55. Dark blue limestone containing seams of calcite..... 4′
54. Dark brownish-gray argillaceous lime shale..... 2′
53. Dark blue argillaceous limestone..... 2′
52. Dark bluish-gray lime shale and light olive calcareous shale..... 7′
51. Dark greenish-gray lime shale..... 1′
50. Concealed. Shaly limestone (?) ..... 7′
49. Dark olive calcareous shale easily weathered..... 22′
48. Massive gray argillaceous limestone..... 5′
47. Fragile dark olive and yellow argillaceous limestone... 10′

46. *Scholarie* and *Caudagalli*, both wanting, but perhaps represented by clay and shale on top of the Oriskany.

No. VII.

Oriskany (Meridian) Sandstone..... 58′

45. Upper part ocherous clay, lower part coarse-grained ferruginous and calcareous sandstone..... 12′
44. Friable sand containing pebbles size of a pea..... 15′
43. Coarse-grained arenaceous sandstone more fragile than above and breaks into more irregular shapes. Mass stained with ferruginous matter and surfaces coated with red hematite. Contains: *Cyrtoceras expansus, Dalmania micrurus, Eatonia peculiaris, Megambonia lamellosa, Orthis hipparionyx, Platyceras ventricosa, Pterinea texilis, Rensselæria marylandica, Rensselæria ovalis, Rensselæria ovoides, Spirifer arenosus, Spirifer arrectus.* Oriskany hermatite ore bed, locally deposited at the lower horizon..... 31′

SILURIAN.

No. VI.

Lower Helderberg.

Lewistown (Pre-meridian) Limestone..... 162′

42. Partly concealed. Upper part composed principally of shaly, argillaceous limestone with probably a few beds of crys-

talline limestone, while the lower part is made up principally of the latter. ..... 30′

41. Massive, dark blue, crystalline limestone..... 42′

40. Massive, bluish-gray limestone, parts of which are characterized by a conchoidal fracture..... 20′

39. Massive, brownish-gray, and blue, crystalline limestone containing alternating beds of gray shale limestone..... 20′

38. Massive, gray, crystalline and dark blue, argillaceous limestone with occasional beds of light gray, shaly limestone and lime shale. Contains: *Acervularia, Alveolites minima, Alveolites, Astylospongia inornata, Merista lævis, Orthis oblata, Pentamerus galeatus, Rhynchonella formosa, Astylospongia, Atrypa reticularis, Aulopora, Conophyllum, Merista arcuata, Stromatopora, Trematospira formosa, Zaphrentis*..... 50′

Water-lime (Scalent) Cement Beds..... 580′

37. Partly concealed. Consisting for the most part of blue and gray, thinly laminated, argillaceous limestone..... 150′

36. More massive, bluish-gray, argillaceous limestone thinly laminated. The massive strata have a conchoidal fracture... 110′

35. Massive, dark gray and bluish-gray limestone, surfaces coated with carbonaceous matter and showing "slicken sides." Also contains calcite with a marked cleavage. Lower part contains impressions of fucoids and bivalve shells..... 30′

34. Partly concealed. Similar to No. 35 but containing lime shale..... 90′

33. Massive bluish-gray limestone alternating with slaty argillaceous limestone and green and yellow calcareous shale. 50′

32. Partly concealed. Principally yellow and gray, argillaceous lime shale..... 60′

31. Gray and bluish-gray, slaty, argillaceous limestone and shale..... 20′

30. Thinly laminated, blue and yellow argillaceous limestone alternating with gray lime shale..... 20′

29. Brownish-gray and gray, slaty limestone containing seams of calcite..... 30′

28. Bluish-gray slaty limestone and lime shale..... 20′

Onondaga (Salina) (Scalent) Marls..... 440′

27. Yellow, brown, gray and green, argillaceous and calcareous shale..... 20′

26. Partly concealed. Composed principally of olive and gray calcareous shale..... 50′

25. Gray, shaly limestone alternating with olive, calcareous shale..... 100′

24. Partly concealed. Composed for the most part of yellow

and green, calcareous shale alternating with red, argillaceous shale... ..... 70′

23. Partly concealed. Composed for the most part of green, yellow and gray, calcareous shale alternating with red shale.. 150′

22. Olive and gray, calcareous shales with a few alternating beds of red shale..... 50′

No. V.

Clinton (Surgent) Red Shale..... ..1145′

21. Red, sandy shale containing irregular deposits of green shale. The red shale is more silicious and massive toward the upper part, where it exhibits a rhombohedral fracture..... 120

20. Partly concealed. Probably composed of red, argillaceous shale containing alternations of green and gray, calcareous shale..... 100′

19. Red, shaly sandstone containing irregular seams of calcite, becoming argillaceous toward the bottom..... 50′

Clinton upper Olive Shale..... 162′

18. Gray, olive and yellow, calcareous shale containing seams of blue, fossiliferous limestone..... 30′

17. Olive and olive-brown, argillaceous and calcareous shale containing seams of blue, fossiliferous limestone..... 80′

16. Similar to No. 17, but containing more seams of limestone toward the bottom..... 40′

15. Blue and gray, argillaceous limestone alternating with dark olive shale ; lower part composed of light yellow, argillaceous lime shale, forming the hanging wall of the fossil ore bed. The Clinton upper olive shale contains the following fossils, more particularly in the lower part : *Atrypa reticularis, Beyrichia lata, Buthotrephis gracilis, Dalmania limulurus, Homalonotus delphinocephalus, Orthis elegantula, Platyostoma niagarensis, Pterinia emacerata, Rhynchonella neglecta, Strophomena rhomboidalis*..... 12′

Clinton Ore Rocks..... 53′

14. Upper fossil ore bed..... 10″
13. Red sandstone and white shale..... 12″ } 3′
12. Lower ore bed..... 14″

These are asserted to be safe average thicknesses of these three beds, by H. G. H. Tarr, Superintendent of Rock Hill Iron and Coal Co. at Orbisonia.

11. *Ore Sandstone.* Its upper part is composed of massive, yellow sandstone under ore bed at Rockhill, while at Saltillo the upper part is very calcareous. The central part is composed of yellow and green, fossiliferous sandstone (crinoid stems) alternating with shale, while the lower part becomes much more massive ..... 50′

Clinton lower olive shale..... 660′

10. Yellow, gray and green, argillaceous shale weathering olive and claret color, near the lower part the surfaces of the shale are stained with iron and bituminous matter..... 600′

9. Same as No. 10. Lower part containing soft olive shale, showing impressions of crinoid stems (Three Springs), and red shale (Rockhill), containing by analysis 4.29 per cent. of metallic iron..... 60′

No. IV.

Medina (*Levant*) *Sandstone*..... 1330′

8. Massive, white and light gray, fine-grained, hard sandstone alternating near its upper limit with beds of red and greenish shale. Contains *Arthrophycus harlani*..... 400′

7. Soft, argillaceous brown and red sandstone and shale, the sandstone in the central part softer, and more friable and contains specks of ferruginous matter..... 930′

Oneida (*Levant*) *Sandstone*..... 568′

6. Red and greenish gray, silicious breccia and conglomerate. 158′

5. Hard, massive, greenish sandstone and gray conglomerate. 410′

No. III.

Hudson River (*Matinal*) *Shale*..... 1870

4. Brown and bluish-gray shales and sandy slates, containing especially in upper part beds of argillaceous sandstone. A reddish-gray shale in upper portion contains crinoid stems... 800′ ±

Utica (*Matinal*) *Slates.*

3. Brown, brownish-gray and black fissile slate, parts very carbonaceous, toward lower part becomes slightly calcareous. 1070′ ∓

No. II.

Trenton (*Matinal*) *Limestone.*

2. Dark blue and bluish-gray, soft, argillaceous limestone, alternating with blue, calcareous shale particularly toward its upper limit..... 500′ (?)

Calciferous (*Auroral*) *Magnesian Limestone.*

1. Massive, light-bluish-gray, magnesian limestone. Upper part only exposed, lower horizon below surface of erosion.... ——

No. I.

Potsdam Sandstone below the present surface.

NOTES *to explain the above Section.*

The Section, although a continuous one of Carboniferous, Devonian and Silurian strata, is subdivided into groups which represent the long since recognized and generally accepted formations of the State Geological Reports of New Jersey, Pennsylvania and New York.

The original numbering of these formations from I to XIII is the oldest attempt at a subdivision of the Palæozoic system, having been made in 1836. The numbers were used as a provisional nomenclature in publishing the Annual Reports of the First Survey of Pennsylvania. They have been used more or less in all subsequent surveys by geologists. They are retained in this section as convenient symbols for ready reference, although they have lost much of their lithological and still more of their palæontological value.

The geographical nomenclature of the New York Final Reports of 1843 and 1844, as well as the more poetical names afterwards adopted by Professor Rogers for his Geology of Pennsylvania, published in 1858, are given with the numbers, although the formations to which they have been assigned do not in all cases exactly correspond as to their upper and lower limits.

Some new names will also be noticed, chiefly near the top of the section. *Pottsville Conglomerate, Mauch Chunk Red Shale* and *Pocono Sandstone* are geographical synonyms for XII, XI and X,—or for *Seral, Umbral* and *Vespertine,*—proposed by the present State Geologist, to fill the gap at present existing in the *geographical nomenclature* of the Palæozoic rocks between the Catskill Formation and the Alleghany River Coal Measures. As IX and X together make up the mass of the Catskill Mountains, yet have always been regarded as separate formations, and as there is a geological objection to distinguishing them as Lower and Upper Catskill, the fact that X constitutes the mass of the Pocono Mountains in Pennsylvania, has been taken advantage of to provide it with an analogous geographical and euphonious name.

Mauch Chunk and Pottsville, where XI and XII have their maximum development, are important and well-known places, and there seems to be no valid objection to applying these names to those formations.

Much lower down in the Section a subdivision of the Lower Helderberg group, a limestone formation of unusual thickness, is named from the borough of Lewistown, one of the most important places on the Juniata River, where this limestone attains its maximum of size. A special name for the limestoue is called for, because it cannot yet be certainly identified with any special one member of the Lower Helderberg Series.

As to the thicknesses assigned to the divisions and subdivisions of the Section, it must be understood that they were obtained partly by direct

measurement of single outcrops, or series of outcrops,—partly by geometrical construction of a vertical section along one line, and by means of occasional, but neighboring outcrops,—and partly by construction on one or more lines of observation.

The planes or horizons between the groups and formations of the Section are in some cases arbitrarily assumed, being based exclusively neither upon lithological nor palæontological grounds, as the descriptive text of the section shows. In a number of instances the division or subdivision line has been necessarily drawn at the end of an exposure, or at a sudden break in, or change of, the topography.

The section must therefore be taken only for what it is worth, but by no means as a complete, authorative or final statement of the constitution of the Palæozoic system in Middle Pennsylvania. Many of its lacunæ will no doubt be filled up by future explorers, and some of its zero points shifted the better to agree with the true succession of deposits.

No. XIII. Alleghany River (Lower Productive) Coal Measures.

The Mahoning Sandstone at the top of the Section has commonly been considered the base rock of the Barren Measures, or Lower Barren Measures, of the great Bituminous Coal Field of Western Pennsylvania. But as it may with equal propriety be accounted the top rock of the Lower Productive Coal System (being in fact known as "The Top Rock" on Broad Top), and as the Alleghany River Coal Series must be taken (as Mr. Platt's report on Somerset Co. will show) to include the entire 800 feet of Coal Measures from the Pittsburgh Coal Bed down to the Pottsville Conglomerate (or even lower still), no mention of Barren Measures has been made in this Section.

The Mahoning Sandstone, No. 267 of the section, caps the hill to the north-west of Robertsdale in the East Broad Top or Trough Creek Coal Basin, where the top of the section ends. It is given a thickness of 90 feet; a portion of it may have been eroded from the surface of the hill.

The coal measures beneath it (Nos. 266 to 251 inclusive,) are 174 feet thick and consist of shales, slates and sandstones, containing 3 workable seams of coal (2 benches each). On account of a number of rolls in the strata and the varying dip of the rocks at Robertsdale, where the coals have been most extensively developed, and for the want of a system of levels throughout the workings on the coal seams, it was impossible, with any degree of certainty, to determine the precise intervals between the several coal beds. The given thicknesses between the coals are only approximate, and may be found to vary as much as 10 feet, although the total thickness of the series is probably as fair an estimate as can be made. If the classification which is proposed for the coal seams shall be verified by actual development, it gives us a means of comparison with the Alleghany series in Western Pennsylvania.

XII. *Pottsville (Serai) Conglomerate, (Millstone Grit).*

Upper member	(Piedmont sandstone) No. 250.....	160′	280′
Middle "	(Kanawha River series), Nos. 249, 48, 47, 46..	40′	
Lower "	(No. XII proper) Nos. 245 and 244.....	80′	

1. *The Upper member*, or (Piedmont sandstone) consists of three parts: upper white and reddish-white and gray, flaggy sandstone and conglomerate; in the middle part the conglomerate predominates, the pebbles here being the largest, but very irregularly distributed, while the strata themselves exhibit false bedding in a marked degree. The lower part of this member is composed, principally, of thinly bedded and conglomeritic sandstone.

The beds of conglomerate do not seem to be persistent. It would appear as if a bed, in force in one locality, feathers out from a centre of maximum thickness in all directions and disappears entirely, while an upper or lower conglomerate bed has its minimum thickness at the very locality where the other is at its thickest.

Dr. Newberry, in Vol. II, Geology of Ohio, p. 107, suggests the origin of the conglomerate in No. XII as being due to icebergs. He says, "From the similarity of the deposits now being made by icebergs, over various portions of the sea bottom, with those made by the same agency during the Drift Period, and of both to the materials composing the carboniferous conglomerate, I have suggested the possibility that they might all be products of the same agency. In this view the conglomerate should be compared with the kames and eskers of the drift. This theory, however, is not insisted upon, but is simply a suggestion, which has sprung from a conviction of the entire inadequacy of any other solution of the problem yet offered."

2. *The middle member*, or Kanawha River Coal Series, so named from its great development along the Kanawha River, in West Virginia, consists of sandstones and shales containing a seam of coal, No. 248, about 2 feet thick, which represents undoubtedly the Mount Savage coal bed. This set of beds resembles strongly in general character the rocks of the lower productive coal measures.

The coal bed No. 248 is overlaid by sandstone and shale No. 249, and underlaid by massive gray sandstone No. 247, exhibiting false bedding, with probably a bed of fireclay between the sandstone and coal. The seam was located in many places on Wray's Hill and Rocky Ridge, but there was only one locality (Rocky Ridge, west end of Wray's Hill tunnel) where its thickness could be determined and it was impossible on account of water in the opening to ascertain the exact nature of the underlying stratum.

No. 246 at the bottom of the middle member is 7 feet thick and (17 feet below the coal seam) is composed of dark gray and black slate and slaty sandstone; the slate predominating. A small seam of coal was reported to have been found in the black slate, but it is a little doubtful, as no traces

of its existence could be found, although some parts of the slate itself seem to be slightly carbonaceous. The whole member is quite argillaceous and contains a great deal of oxide of iron, which, on weathering, renders the surfaces of the strata of a dull brown color.

3. *The lower member*, or Conglomerate proper is for the upper ten feet composed of (No. 245) hard, massive, gray sandstone; the surfaces are very much coated with iron, and the layers contain a great many floral impressions (lepidodendra, calamites and sigillaria).

The remaining 70 feet of this member consists (in the upper part) of a hard, massive, gray and white sandstone and conglomerate, the latter predominating toward the central part, where the pebbles are larger. In the lower part there is less conglomerate, the sandstone becoming dark gray and flaggy and containing micaceous specks.

A careful study of the section reveals some very sharp horizons between sandstone, shale and slate, and coal and sandstone, conveying the idea of sudden and great changes of the conditions attending the deposit.

In Clinton county, in north central Pennsylvania, I have measured the conglomerate (probably lower member) and found it only 25 feet thick. To the south-west of Broad Top the series expands very rapidly, the expansion taking place in the middle member. At Pottsville No. XII is 1030′ thick.

On the Kanawha River, in Raleigh Co. West Virginia, Prof. W. M. Fontaine reports the following section (Silliman's Journal, April, 1876):

Upper conglomerate 150 to 200 feet thick.

Kanawha coal series (Fontaine's New River Series), composed of sandstones, shales and slates, containing nine seams of coal, whose aggregate thickness is 20 feet. The coals occur in the centre and toward the top of the series. Thickness 967 feet.

Lower conglomerate, thickness 80 feet.

The thickness of the upper and lower members at Broad Top and on the Kanawha River is the same, while the middle (coal-bearing strata) on the Kanawha is 24 times thicker than the same series at Broad Top.

A number of years ago Prof. Lesley reported on two workable beds of coal in Montgomery county, Virginia, and his discovery of more than a dozen coal beds along the western flank of Peak Mountain in Wythe County, in No. X. and named the coal series after the New River. This name, takes precedency of Prof. Fontaine's name of New River, applied in recent publications, to the Conglomerate coal series, of No. XII which Mr. Lesley therefore proposes to call the Kanawha River series.

No. XI. *Mauch Chunk (Umbral) red shale.*

Upper member	(shales and sandstones) 243 to 232.....	910′	
Middle "	(mountain limestone) 231 to 221.....	49′	1100′
Lower "	(shales and sandstones) 220 to 213.....	141′	

1. *The upper member* is made up of red shales and sandstones, with alternations of gray, flaggy sandstone and shale. Its upper limit is well-defined by a gray mottled carbonate of iron, No 243, which, along its out-crop has

been oxidized by the action of the atmosphere, and is changed from a proto-carbonate of iron into a brown peroxide.

In many places on Wray's Hill in Todd and Carbon Townships, the blossom of the ore bed, along its outcrop, is a silicious and shaly brown hematite, and on Iron Knob, directly to the south of Wray's Hill tunnel, loose fragments of the ore were found as a very silicious brown hematite associated with and containing pieces of red and green shale.

The lower limit of this upper member is placed on the red, shaly limestone of the middle member. The three-fold character of the upper member, which Professor William B. Rogers mentions as being everywhere discernible in Virginia, is to some extent to be noticed here, for we have the upper 209 feet formed of variegated and alternating red and gray sandstones and shale; directly below this 524 feet of harder strata composed principally of gray and red sandstones, flags and shale, the upper part exhibiting false bedding; while the 177 feet immediately above the limestone are made up of red shales and sandstones, the former predominating. We then have the following sub-divisions of this upper member :—*a*, from Nos. 243 to 239 inclusive ;—*b*, from 238 to 233 ;—*c*, 232.

The No. 242 seems to be a persistent associate of the overlying ore bed, it is extremely argillaceous and at times seems to be formed of clay. Small specks of carbonaceous matter were found scattered through the mass on the southeast flank of Wray's Hill near the road crossing to Cook's station.

No. 241 is, probably, more variable in character than 242. In some localities it seems to change into, or be replaced by, red shale, not being distinguishable from 240.

No. 240 and 239 are more like argillaceous marlites, easily weathering, and producing a deep red soil.

On account of the very imperfect exposure of this part of No. XI, the section may not reveal the minuter and more important alternations of the strata which doubtless exist.

Professor Rogers (Final Report, Vol. I, p. 531) says, "These strata become more silicious as they approach the Conglomerate, and in the form of green, buff and hard reddish argillaceous sandstones embrace impure calcareous beds." The relative position of these beds will appear from the following observations made on the west flank of Broad Top Mountain, half a mile below Riddlesburg.

(17.) No. XII, seral conglomerate not 100 feet thick, the lowest coal bed above it being only about 100 feet above the limestone No. 14.

(16.) Interval of a few feet unknown.

(15.) Silicious slate, dull brown color, 10 feet.

(14.) Limestone, hard, silicious, reddish, embracing plates of red shale; its fragments strew a blank space of 40 feet, occupied probably by red shale below its apparent outcrop.

(13.) Sandstone, fine-grained, micaceous, green, passing downwards into olive shale, 20 feet.

(12.) Sandstone, gray, 3 feet (exposed).

(11.) Interval, 10 feet, probably red shale.

(10.) Sandstone, laminated, greenish-gray, micaceous, 3 feet (exposed).

(9.) Shale and fine, micaceous, argillaceous sandstone, 20 feet.

(8.) Sandstone, ferruginous, massive, close-grained.

(7.) Sandstone, coarse-grained, massive and distinct quartz grains in contact, apparently cemented by an oxide of iron resembling the Clinton Block ore near Beavertown, Union County. Thickness 3 feet.

(6.) Sandstone, rather massive, greenish, interstratified with green and red shales, 20 feet.

(5.) Sandstone, dirty green, pretty compact, becoming micaceous downwards, brown and very ferruginous, 13 feet.

(4.) Limestone, greenish, very silicious with pebbles and plates of green shale, hard and weathering with a worm-eaten aspect, 2 feet.

(3.) Sandstone, green, argillaceous, micaceous, laminated, 7 feet.

(2.) Interval, 45 feet.

(1.) Sandstone, light brown, micaceous, laminated: beneath the red shale at the river bank.

This section from the base of the Conglomerate No. XII down to the bottom of (2) shows a measured thickness of 196 feet, with two unmeasured intervals, (8) and (16.)

The whole aggregate thickness from the base of No. XII to the red shale at water level would probably be between 200 and 220 feet. The distance between the two sections at Wray's Hill and Riddlesburg is about 9 miles (air line). As the thickness of No. XI in that distance would probably not vary appreciably, the Riddlesburg section may be said to represent *a* of the upper member at Wray's Hill. The general character of the two is somewhat similar, the difference being no greater than might be expected when the circumstances under which the deposit was made are taken into consideration.

The coal seam, which is mentioned in (17) as occurring 100 feet above the limestone (14) is not, as reported above, in the "lower productive coals," but is an interconglomerate coal found between the upper and lower conglomerate members of No. XII, and probably identical with the coal bed No. 248 of our section.

b. This part is composed principally of gray and red sandstones, flags and shales, and is 520 ± feet thick. It is somewhat harder than the overlying mass and exhibits false bedding in the sandstones toward the top, as seen in Wray's Hill tunnel; the seams along the bedding containing calcite.

The strata here are not as argillaceous as those in the lower part of the member.

"*c.*" The lower subdivision is made up of very argillaceous shales and sandstones, easily weathered, forming a deep red-colored, clayey soil.

At Richmond Falls on the New River, W. Va., this series has a thickness of 1450 feet, distributed as follows: 3. Upper red and variegated

shales, 310 feet. 2. Middle gray and greenish sandstones, 820 feet. 1. Lower red shales and sandstones, 320 feet.

At Quinnimont on the Kanawha River, the transition layers between No. XI and No. XII are shown in the following section :

5. Black fissile slates and shales, 20 feet.....	210′
4. Thinly laminated, gray flags and calcareous shales containing in the upper part carbonaceous shales and strings of coal, 50 ft.	
3. Variegated marlites with some nodular limestones, 70 feet....	
2. Gray calcareous sandstone, 20 feet.....	
1. Bright red shales, seen 50 feet.....	

No coal was found in this series in Huntingdon County.

Prof. Wm. B. Rogers mentions a coal under the Conglomerate on little Sewell Mountain, which he queries equivalent to the Sharon Coal of Western Pennsylvania. He also notes the occurrence of a seam 4 feet thick in subdivision *b* west of Lewisburg, Greenbrier County, Va., and of two beds in Montgomery Co., one from 2 to 3½ feet thick, and the other from 6 to 9 feet thick composed principally of slate.

2. *The middle member* (Mountain Limestone) is made up of red and gray argillaceous limestone and red shale. The limestone and shale alternate so irregularly that it is hardly possible to distinguish any well-marked subdivisions. The whole thickness of this member is 49 feet, the correctness of which depends upon the identification of the variegated red and gray massive limestone No. 224 at New Grenada with that at the quarry worked by John Whitney, near Todd P. O.

The thickness of the series exposed at New Grenada is 35 ± feet. At the quarry worked by Whitney the highest limestone stratum exposed is No. 229, and the lowest No. 221, making 36 feet in all. But if the variegated red and gray limestone bed at New Grenada be the same as that near Todd P. O., then we neither found the lowest stratum at the former locality nor the highest at the latter ; but the lowest exposure at New Grenada is 14 feet above the bottom of the series, while the highest near Todd P. O. is 13 feet below the top. The possible error (in the event of the erroneous identification of limestone No. 224) is 13 feet, which would make the thickness 36 feet instead of 49.

An analysis of the section shows the following divisions :

Upper	Red limestone No 231.....	3′
	Red shale Nos. 229 and 230.....	15′
	Red limestone No. 228.....	2′6″
Middle	Red and gray calcareous shale Nos. 227 and 226.....	5′
Lower	Red and gray limestone Nos. 225, 224 and 223.....	13′
	Red shale No. 222.....	6′
	Gray limestone No. 221.....	4′

On account of the great variability of the limestone beds, the above can hardly be proposed as a distinct division characteristic of the series.

To bring the section into accord with observations made at other localities, in the bituminous region of the State, it might be well for convenience of comparison to divide the series into an *upper* and a *lower* limestone member, separated by a middle mass of shale, as indicated.

Where the limestone was studied in Smith's and Plank Cabin Valleys, the *upper* member is composed of more impure and argillaceous beds than the *lower*, and the only parts of the series which have as yet proved of any very great economical value, are the variegated red and gray limestone No. 224, and the more massive gray stratum No. 223, the latter by analysis containing 92.32 per cent. of carbonate of lime.

In two localities *fossil* remains were found in the *upper* member. In Well's Valley to the south of Broad Top Mountain, near Wishard's old saw mill, a bivalve shell and a coral were found (Roger's Vol. I page 530), and at the quarry near Todd P. O., in Plank Cabin Valley, the following genera and species were collected from stratum No. 228, *Grammysia, Strophodonta, Rhynchonella* and *Terabratula Rœmingeri.* In No. 226 a *Centronella* was disclosed. A close study of the outcrop in Plank Cabin Valley would no doubt result in the finding of other species.

Prof. Rogers (Vol. I, page 472) reports that this limestone series can be traced from the Conemaugh River along Chestnut and Laurel Ridges to the Southern boundary of the State.

"It occurs as a more or less silicious limestone, containing well rounded grains of sand of a light blue color, sometimes having a yellowish tint. The upper part is remarkably full of fossils as is also the central mass of shale."

The series seems to feather to the north on the Alleghany Mountain near the sources of the Conemaugh, gradually augmenting through the southern part of the State and Maryland until in Greenbrier Mountain, Pocahontas County, W. Va., it attains a thickness of 822 feet, known as the Lewisburg limestone. It ranges in force still further south through Eastern Tennessee and Northern Alabama to the end of the Appalachian coal belt in the latter State. In the west the mountain limestone is known as the St. Louis and Chester groups.

Prof. Fontaine (Silliman's Journal, Jan. 1877) proposes the mountain limestone for a base to the Umbral (Mauch Chunk) No. XI ; first, on account of the physical character and composition of the red shales between the Vespertine (X) and the limestone ; second, on account of the subordinate position which the limestone would otherwise occupy in the comparatively restricted Umbral Series.

There are several objections to this classification :

1st. Although the red shale which occurs under the Mountain Limestone undergoes a rapid and progressive attenuation to the west and south-west, the limestone itself is not found in the anthracite region where the Mauch Chunk series has its greatest development, and is a red shale formation

"par excellence," having a thickness of 3000 feet at Mauch Chunk on the Lehigh river.

2d. There is no marked distinction in physical aspect or composition between the lower and upper members of No. XI either in Western Pennsylvania, where the limestone is found, or in Eastern Pennsylvania, where it is entirely wanting.

3d. The topography produced by the upper member of No. X is so different from that produced by the red shale XI below the limestone as to suggest a classical distinction between the two.

The lower member is made up principally of red sandstones and shales; with alternations of coarse-grained, gray and greenish-gray, flaggy sandstones and shales; the latter predominating toward the bottom.

The lower member is devoid of all remains of fossil life, as is also the upper member.

In the layers transitional between the Umbral (XI) and Vespertine (X) occurs an iron ore bed of some local importance in Trough Creek basin. Its precise stratigraphical position was not determined; but it is probably not far above what we have considered as being the top of No. X.

This ore of XI has been developed to some extent at the old workings of the Trough Creek furnace, at the eastern base of Terrace Mountain. "Here the bed occurred in balls closely imbedded in a little earth and was of a number of varieties." (Rogers, Vol. I, page 529.) "Several of these varieties were of a common compact brown ore, seldom exhibiting any hematitic structure, but having a smooth jaspery surface and brittle fracture."

"The Hopewell ore-openings display the ore bed on both sides of the gap cut through Terrace Mountain by Yellow creek. A tunnel 90 feet long reached the ore on the south side of the gap 90 feet below its outcrop, the ore being from 20 inches to 3 feet thick, interposed between the sandstone below and the red shale above, and interstratified with more or less clay. The adjoining red shale lies in thick but very soft strata, is friable and of an intense red color directly below the ore. Thin layers of a more sandy ore are interleaved with the red shale."

The three horizons of economical importance are therefore:

1, that of the Ore bed directly under conglomerate No. XII;

2, that of the Mountain limestone;

3, that of the Ore bed directly above No. X.

No. X.

Pocono (Vespertine) Sandstone.

Upper member (massive and flaggy sandstone), Nos. 212, 211 and 210		610 feet.	
Middle member, 1. Coal bearing strata Nos. 209 to 158 inclusive, (New River series)	313	693 "	2133'
2. Conglomeritic strata, characterized by false bedding, Nos. 157 to 127 inclusive	380		
Lower member (sandstone and shale), (Nos. 126 to 117)		830 "	

The series might be more properly divided into four members ; but as the conglomerate beds and coal-bearing strata of the middle member are always found where coal beds have been discovered, the latter above the former, I have preferred to consider these two formations, which in themselves are so distinct, as constituting one member.

The upper member of the series is composed of coarse-grained, massive, brownish-gray and gray sandstone, alternating with thinly bedded and flaggy sandstones of the same color. Near the top there are a few beds of red shale and sandstone ; and towards the bottom there are beds of black slate containing floral impressions.

The transition of the shales and sandstones of the lower member of No. XI into this upper member of No. X is rather sudden. The bottom of No. XI is rather argillaceous, while the top of No. X is very silicious ; the sandstones in the former (XI) are fine-grained, thinly bedded and flaggy, while those in the latter (X) are coarse-grained, more massive, and recur with fewer alternations of shale than in the former case. The strata are thicker and the change from sandstone to shale less frequent. The upper member of X generally forms the flank of the ridge or mountain whose crest is formed by the lower part of the middle member. The eroded surface of the mountain being very nearly a plane surface, although sloping of course at a pretty high angle, it is seldom cut by streams running transversely to the strike, such as produce the gullies which are so characteristic of that flank of a mountain of Medina and Oneida (No. IV) formed by the Hudson shales ; in fact the drainage is generally effected solely by the stream at the base of the mountain, following it in a parallel direction

The topography of the lower member of No. XI is very marked and quite different from that just described. It generally presents itself as a chain or succession of little hills or knolls, containing the outcrop of the limestone beds of XI, and separated by depressions through which the small streams descending from the flank of the mountain of XII, break just before they join the main stream of the valley flowing along the foot of the mountain of X. In the district lying east of the Broad Top Mountain the place to look for the limestone beds is alongside of and close to the principal stream, which therefore flows along the eroded outcrops of the soft red shales *below* the limestone. This suggests a third reason why the top of the Pocono or Vespertine sandstone should not be considered the base of the mountain limestone.

The middle member of X is subdivided into :

1. Coal-bearing strata, New River series.
2. Conglomerate and conglomeritic sandstone, characterized by false bedding.

The coal-bearing strata contain 19 seams of coal, with an average individual thickness of one inch and a half. Their thickness, if added together and combined with that of the numerous thinner seams and partings

scattered through the strata, and not precisely located in the section, would be sufficient to form a solid seam of coal about four feet thick.

The following analysis of the section shows the position of each coal bed and the feet of interval between, formed generally of sandstone :

29 feet	5 inches.		Sandstone, Nos. 209 and 208,—at the top.
		2½″	Coal (seam No. 19), No. 207.
76 "	3	"	Sandstone, Nos. 206 to 202 inclusive.
		2″	Coal (seam No. 18), No. 201.
1 "	6¼	"	Sandstone, Nos. 200 and 199.
		3″	Coal (Seam No. 17), No. 198.
41 "	4	"	Sandstone, Nos. 197, 196 and 195.
		1″	Coal (seam No. 16), No, 194.
2 "	6	"	Sandstone, No. 193.
		1″	Coal (seam No. 15), No. 192.
	6	"	Sandy fireclay, No. 191.
		1″	Coal (seam No. 14), No. 190.
47 "	1	"	Sandstone, Nos. 189 to 186 inclusive.
		1″	Coal (seam No. 13), No. 185.
6 "	0		Sandstone, No. 184.
		3″	Coal (seam No. 12), No. 183.
6 "	0		Sandstone, No. 182.
		1″	Coal (seam No. 11), No. 181.
4 "	0		Sandstone, No 180.
		3″	Coal (seam No. 10), No. 179.
2 "	0		Sandstone, No. 178.
		1″	Coal (seam No. 9), No. 177.
1 "	0		Sandstone, No. 176.
		1 ′	Coal (seam No. 8), No. 175.
36 "	8	"	Sandstone, No. 174 and shale No. 173 directly above coal.
		1″	Coal (seam No. 7), No. 172.
	1	"	Fireclay, No. 171.
5 "	0		Sandstone, No. 170.
		1″	Coal (seam No. 6), No. 169.
	10	"	Sandstone, No. 168.
		2″	Coal (seam No. 5), 167.
	5	"	Sandstone, No. 166.
		2″	Coal (seam No. 4), No. 165.
17 "	0		Sandstone, Nos. 164 and 163.
		2″	Coal (seam No. 3), No. 162.
28 "	0		Sandstone, No. 161.
		1″	Coal (seam No. 2) No. 160.
5 "	0		Sandstone, 159.
		1″	Coal (seam No. 1), No. 158, at the bottom.

Fireclay occurs only under seams No. 7 and 15 ; that under No. 15, being very sandy.

The sandstone between the several seams has a great sameness of character, and is very much broken up by false bedding and fractures; in many cases it contains thin seams or partings of coal. The numbered seams and partings generally lie parallel with the true bedding of the strata, although in many instances *they are found along the planes of false bedding.* The thicknesses are very variable, in places increasing from 1 and 2 inches up to 10 inches and 1 foot; and sometimes a seam will be very much broken up and separated by a mass of sandstone, which splits the bed for some distance, but afterwards disappears, permitting the severed portions to unite again.

The almost total absence of fireclays under the coal seams, and the occurrence of coarse sandstone in many places directly above them seems to show that the coal has been derived from plants which may have grown at some distance from the locality and been afterwards floated and caught in the falling sediment, forming "drift beds." The period was undoubtedly one of continuous local current agitation as indicated by the coarseness and false bedding of the strata.

The lower part of the middle member is characterized more particularly by its beds of conglomerate and conglomeritic sandstone, both of which exhibit false bedding in a marked degree.

At the top of it directly under coal seam No. 1, comes No. 157 of the section, 25 feet thick, composed of soft black shale containing plates of coal and impressions of minute plants, alternating with a fine-grained conglomerate which contains micaceous specks. The surfaces of the shale are very much stained with iron. Directly below these alternating beds occur (No. 156) 26 feet of a yellowish-gray argillaceous shale also containing plates of coal and showing "slickensides," giving evidence of some contortion and slipping of the strata.

The first well defined and massive sandstone (No. 155 of the series) occurs below the shale; is 9 feet thick and is separated by 2 inches of black carbonaceous slate (No. 154) from 113 feet (Nos. 153, 152 and 151) of hard massive and conglomeritic sandstone, *showing a greater amount of false bedding than any other part of the section.* No. 152 contains a few alternating beds of black slate, but is *en masse* the hardest and most massive part of the Pocono or No. X epoch. It forms the crest of Sideling Hill, apparently throughout its whole extent; its position in the mountain can be seen both in Sideling Hill creek section and E. B. T. R. R. section accompanying the report of the Aughwick Valley. Below these harder and more massive strata there are 82′ 7″ (Nos. 150 to 144 inclusive) of shale, with a few beds of sandstone, the whole underlaid again by 25 feet of hard, massive sandstone (No. 143), and 13 feet (No. 142) of fine-grained conglomerate containing thin beds of black micaceous sandstone.

The general character of the section below this part is as follows:

Shale and sandstone (No. 141)	26	feet.
Massive sandstone showing false bedding (No. 140)	17	" 0

Shale and sandstone (Nos. 139 to 136 inclusive)	5 feet 9
Sandstone (Nos. 135, 134, 133)	17 " 10
Shale (Nos. 132 to 128 inclusive)	4 " 6
Sandstone and shale (No. 127)	15 " 0

The sandstone and conglomerate, throughout the whole series, seem to alternate with the beds of shale as shown in the following grouping :

Shale	51′	380′
Sandstone	122′	
Shale	83′	
Sandstone	38′	
Shale	26′	
Sandstone	40′	
Shale	5′	
Sandstone	15′	

Throughout the upper member of this Pocono or Vespertine Formation No. X, and the coal-bearing strata of the middle member, remains of a terrestrial vegetation are more or less abundant both in the sandstone, shale and slate. The following genera and species have been determined by Prof. Leo Lesquereux in specimens collected from the débris at the west end of Sideling Hill Tunnel :

1. *Sphenopteris flaccida* (Crépin), a new species for America but recently discovered in Belgium, stage of the *Psammites du Condroz,* which correspond to the upper part of the Catskill (IX) of Pennsylvania ; for the same formation has still a *Psilophyton* and *Palæopteris hybernica.*

2. A species of *Ulodendron* with scar leaves obsolete. It seems to be quite near to if not identical with *Ulodendron majus* (Sternb.), a species found in the sub-conglomerate coal of Alabama, but ascends to and above the Conglomerate.

3. *Knorria acicularis* Göpp, from the transition measures of Silesia. It is new for this country but passes by decortication to the following:

4. *Stigmaria minuto* Lesq. First Geological Report of Pennsylvania, Plate XVI, fig. 1 and 2, from the Pocono (Vespertine) of Mauch Chunk.

5. A branch referable to *Stigmatocanna Wolkmanniana* Göpp, but not positively ascertainable, the bark of the tubercles being destroyed.

6. A *Lepidodendron* (?) in four twisted and compressed fragments, so much deformed that the outlines of the scars are not discernible.

Nos. 1 and 4 are the more predominant species and are represented by many fragments.

"The specimens were very hard to study and determine, as they are twisted in many directions and the vegetable fragments covered with a coating of coal as hard as graphite."

3. The *lower member* in its general character bears some resemblance to the upper member in as far as it is made up of alternations of sandstones and shales.

The sandstones are more argillaceous and not as massive; they are coarse grained and stained with iron, and at times contain red and yellow specks.

The shales are both argillaceous and silicious, and the alternations with the sandstone are more frequent than in the upper member.

The predominating colors of the sandstone and shale are gray, yellow, olive and green.

This member seems to contain more ferruginous matter disseminated through the strata than either of the other members, and quite frequently iron concretions are found.

The horizon between the Pocono (X) and Catskill (IX) is not very distinctly marked. The greatest distinction between the two is that of color. The upper strata of the Catskill are more argillaceous than those at the bottom of the Pocono, which fact in a measure determines the topography of the two.

Prof. W. M. Fontaine, in Silliman's Journal for January and February, 1877, gives a description and section of the Vespertine (Pocono, X) in West Virginia.

In Lewis Tunnel through the Alleghany Mountain, on the Chesapeake and Ohio R. R., he has constructed the following section:

135 feet. Upper part (30 feet) dark shales, olive and reddish marlites, below which occurs 10 feet of firm thin bedded black shale holding a local coal 12 inches thick. The lower half is composed of firm, silicious, rather coarse bluish-gray sandstone holding bits of lower rocks, drifted stems and coal beds.

Below this mass come the coal-bearing strata 215 feet thick, distributed as follows:

15′	Black sandy slates.
3′	Sandstone.
6″	Coal, slaty.
5′	Fireclay containing rootlets.
2″	Coal.
1′	Fireclay.
30′	Gray sandstone with films and streaks of coal (floated).
1′	Black slate and coal.
3′	Brown flaggy sandstone.
8″	Coal.
5″	Fireclay.
5′	Bluish-black sandy shales.
50′	Gray flags.
—	Interval (?) feet thick.
20′	Olive sandstone.
40′	Argillaceous thickly bedded sandstone with thin films of coal and black shale.

Below this series occurs a white, pebbly, silicious sandstone, very persistent, at least 60 feet thick, the mass directly underneath being concealed.

From the base of this sandstone to the top of the red marls and sandstone (No. IX) there is a thickness of 500 feet, more or less, made up of flaggy sandstone with interstratifications of shales, all of which when fresh have a dingy yellow or brownish-gray color, but weathering to a dull brown.

Professor Fontaine seems to prefer calling the 60 feet at the base of the coal-bearing strata the base of No. X, but further states that the underlying 500 feet might perhaps be thrown into the Vespertine or Pocono Epoch. Judging from Fontaine's descriptions, to bring the section in harmony with the East Broad Top, I think it would be necessary to consider the lower 500 feet as included, making a total thickness for No. X of 910 feet, more or less, which would then be represented by 2133 feet at Broad Top, reversing the relationship in the two localities between No. XI and No. XII, both of which are thicker in the Virginia section than at Broad Top.

The general sections of Prof. Fontaine's, given in the text, I have compiled from his elaborately detailed descriptions in Silliman's Journals, to which the reader is referred.

No. IX.

Catskill (Ponent or Old Red) Sandstone.

Thickness (Nos. 116 to 108 inclusive), 2680 feet.

Character: consists for the most part of thick alternating red argillaceous shale and sandstone, and occasional beds of gray, yellow, white and green sandstone and shale. On account of its uniform composition it does not admit of sub-division either by its fossils or mineral composition. Unlike the groups of Nos. X, XI and XII, which gradually assume new phases, this series, undergoes no important modification other than that of thickness throughout the State.

The *upper* part of No. IX is composed of red shale and sandstone alternating with gray and whitish sandstone, containing micaceous specks. The *central* part seems to be made up principally of red flaggy sandstone and shale alternating with thin massive yellow, gray and white shaly sandstone; toward the bottom the red shale becomes more sandy, contains less alternations of gray shale and a number of imperfect remains of what apparently was a terrestial vegetation, the accumulation in some localities being sufficient to form small "drift beds" of coal. The *lower* part seems to contain a predominant amount of ferruginous matter, and the surfaces of the strata are sometimes slightly stained with a bituminous coating. No fossils were found in this mass other than a few remains of fish bones and scales, having a white and bluish tint in contrast with the red and brownish-red shale. The strata throughout the whole formation are very argillaceous, weathering very easily, which fact is beautifully illustrated in the deep cuttings made recently in Smith's Valley, on the line of the E. B. T. R. R.

Prof. Hall gives the following description of it as studied by him in Eastern New York:

"The Old Red Sandstone, where fully developed, consists of various

strata of sandstone, shale and shaly sandstone, conglomerates and impure limestones. The pervading color of the sandy parts is brick red, though often lighter, and sometimes of a deeper color, from a larger proportion of iron; while the coarser parts are often gray and the shales are green. Beds of green shaly sandstone are interstratified with the red friable sandstone, and these are succeeded by a compact kind of conglomerate rock."

The following section of the Red Catskill is given by Prof. Fontaine (Silliman's Journal, January, 1877), constructed near Lewis Tunnel on the Chesapeake and Ohio R. R., W. Va.:

No. 3,	150′ ±	Red marl and sandstone, containing more sandstone than No. 2.	340′
No. 2,	70′	Dark red marlites with ochreous and very argillaceous sandstones. Balls and nests of limonite and decomposed pyrites.	
No. 1,	120′	Deep red marlites alternating with thick bedded and argillaceous reddish-brown sandstones in about equal proportions. These are underlaid by coarse sandstones containing Chemung fossils.	

No. IX is between 1,000 and 2,000 feet thick where it outcrops south of the anthracite coal fields, and on the south flank of the Catskill Mountains in New York. In the northern counties of Pennsylvania and in the north flank of the Catskill Mountains (N. Y.) it is probably between 400 and 600 feet thick.

This Formation forms the mass of the Catskill Mountains of New York, and the middle flank of the Pocono Mountains on the Pennsylvania side of the Delaware River. After passing the Lehigh River, its strata assume a vertical attitude, and the outcrop of its harder parts makes the southern of the two crests of the Second Mountain nearly to the Susquehanna River. Wherever the dip approaches 45° the red Catskill sandstones of IX form a bold terrace on the flank of the mountain, the crest being made by the Pocono sandstone of X, as in Peter's Mountain, at the mouth of the Juniata. Along the face of the Alleghany Mountain, this terrace of IX is cut up into a series of buttresses projecting from the escarpment. Around Broad Top the same *terrace structure* has given occasion for the name Terrace Mountain, which is merely the prolongation (in a curve backward) of the Sideling Hill which our Section crosses.

The formation contains in the Broad Top country no stratum of any economical importance. An iron ore bed occurs about 400 feet below the upper horizon. Its thickness is undetermined, and it was merely located from its outcropping on the north-west side of Smith's Valley, where it occurred as a very silicious brown hematite. It will probably never prove to be a workable bed.

Transition strata between the Catskill and Chemung epochs:

Thickness (Nos. 107 to 96 inclusive) 90 feet.

Character: Consists of yellow, red, green and olive shale and sandstone.

The surfaces of some of the sandstone strata contain a fine exhibition of ripple marks and impressions of fucoids and characteristic Chemung fossils, *Spirifer disjuncta*, *Rhynchonella*, &c.

Thirteen feet from the bottom occurs a brown ferruginous sandstone, No. 101, weathering readily on the surfaces from the oxidation of the iron, the representative of the Larry's Creek ore, which has a continuous range through parts of Lycoming, Clinton and Tioga counties. It attains its maximum thickness on Larry's Creek in Lycoming County, where the principal bed is 3 feet thick. In some localities it resembles closely the Cleveland ore of Yorkshire, England. In this portion of the State the bed is not workable.

No. VIII.

Chemung (Vergent) shales.

Thickness (Nos. 95 to 85 inclusive), 1860 feet.....

Portage (Vergent) flags. } = 3310′

Thickness (Nos. 84 to 71 inclusive), 1450 feet.....

The limits of the Chemung and Portage taken together are well defined, the upper being topped by the transition strata at the base of the red Catskill, and the lower by the olive slaty and shaly sandstone of the Hamilton period. The horizon between the two epochs is not as well defined and it has been located rather arbitrarily. There are certain large distinctions between the two which it may be well to notice before describing each in detail.

Both are made up of alternations of shales and sandstones. In the Chemung the strata are more silicious, while in the Portage they are more argillaceous. In the latter the sandstone is always finer grained and the shale more clayey than in the former. The Portage sandstones are flaggy and at times very shaly, and their alternations with the shale are very frequent, although the individual strata are quite thin, the shale predominating. The sandstones of the Chemung are more massive, occur in thicker strata, their alternations with the shale are less frequent and they seem to contain more ferruginous matter, and more micaceous specks. The Chemung strata, particularly the shaly sandstones toward the top, are replete with marine mollusca, particularly brachiopods, while the Portage is extremely poor in fossil life, with the exception of crinoid stems and sea weeds, or fucoids; although the occurrence of fossil fucoids would not distinguish the epoch, since they are also very abundant in the upper part of the Chemung, but possibly the two are of different types.

The *upper part of the Chemung* is composed of olive-brown and gray massive and sometimes argillaceous sandstone alternating with flaggy sandstone, and red and green shale, both shale and sandstone containing ferruginous specks.

The *central portion* of the epoch is made up principally of brown, red and gray sandstone and shale: the sandstone is probably more massive than

it is in the upper part, and besides ferruginous matter contains micaceous specks.

In the *lower part* the general character of the strata is very much the same, although apparently containing less iron and mica than the central part.

In descending from the top to the bottom of the epoch the sandstone which in the upper part seems to predominate, diminishes, while the shale increases, and the alternations of the two are greater, although of course the sandstone strata must be thinner. The upper part contains the greatest number of remains of fossil life.

The *general character of the Portage* seems the same throughout. The upper part is composed of rather massive brown and gray sandstone alternating with beds of olive and gray shale from 10 to 30 feet thick. Toward the centre the sandstone becomes more flaggy and occurs in thinner strata, while the shale becomes more argillaceous, forms thicker beds and is more varied in color. As we approach the lower horizon the sandstones become thinly laminated and occur in beds but a few inches thick; the shale is extremely argillaceous and weathers readily into clay. The shale, throughout the whole epoch, contains more or less iron, which on exposure readily washes out and is oxydized on the surface, coloring the shale in various shades of yellow, brown and red.

In New York, Prof. Hall reports (1843) that "the upper part of the Chemung is characterized by a general tendency to conglomerate, or gravel. In a few localities the mass becomes a well characterized pudding-stone. This conglomerate (continues Mr. Hall) nowhere attaining sufficient thickness or importance to merit a distinct description."

It is worthy of notice that this conglomerate, which forms several notable "rock cities" in South-western New York and which, probably, is the northern extension of one of the sands of the oil group of Western Pennsylvania, seems to be without even a representative at Broad Top. Although the sandstones toward the top of the Chemung are massive and coarse grained, yet there seems to be no tendency to conglomerate or gravel.

Again, cross lamination, or oblique, or current bedding, ripple marks, concretions and limestone strata which are so abundant in the Chemung and Portage Epochs in New York, are wanting in Central Pennsylvania. The ripple marks in a measure are an exception to this assertion, although they are comparatively rare, and though sometimes met with, they would not be difficult to overlook, especially after studying the fine exposures in the transition layers between No. VIII and No. IX along the E. B. T. R. R., those in the lower Catskill in Smith's Valley, and again in the bottom of the Hamilton on the Aughwick near Potts's Gap.

The absence of the limestone or limy shale and concretions may be attributed to the limited remains of marine life. These in New York are found in great colonies. Not only do we not find any limestone or limy shale, but the whole period is particularly devoid of any calcareous matter

in the cementing material of the sediment. This is readily shown by the rapid weathering of not only the shale but also the harder sandstone strata in the cuts along the E. B. T. R. R.

Professor Rogers (Final Report Vol. I, page 141) says of the Chemung: "This formation, remarkable for its general uniformity of composition, appears to have its maximum development in the region of the Juniata near Huntingdon, half way across the Appalachian chain, where its thickness is 3200 feet." Without reference to its thickness and character in other localities our measurement of its thickness (1950 feet) near Huntingdon seems to show that the above generalization is hardly well founded.

The Chemung formation makes both ridges and valleys. The upper part forms a ridge parallel to the mountain of X. The valleys are generally narrow and sharp, for the most part running parallel with the strike.

Portage rocks make also ridges and valleys, the ridges not as prominent as in the Chemung, and the valleys and ravines more irregular, not having such a great tendency to be parallel with the strike of the rocks.

The mass contains no strata of economical importance. Some of the sandstones are quarried to a limited extent for building stone. The sandstones and conglomerates forming the "oil sands" of north-western Pennsylvania, which are perhaps cotemporaneous with the Chemung Epoch, have no representative at Broad Top.

Genesee (*Cadent Upper*) *Slate.*

Thickness: (Nos. 70 to 67 inclusive) 325 feet.

Character: Consists of olive, slaty and shaly sandstone alternating with brownish-gray flaggy sandstone and dark olive shale; toward the lower part the sandstone strata disappear, and the shale becomes more argillaceous, until finally at the bottom we have dark olive fissile slate with occasional seams of a bright brown-colored sandstone from 2 to 4 inches thick. The shale and slate are slightly bituminous and stained with iron.

These rocks form valleys and are of no economical importance.

Hamilton (*Cadent*) *Shale.*

Thickness: (Nos. 66 to 63 inclusive) 635 feet.

Character: Consists in the *upper part* of gray sandstone flags and shales; toward the central part the sandstones predominate in a three-fold character of massive, flaggy and slaty, to the exclusion of the shale. Surfaces of the sandstones are stained with iron and contain the following fossils: *Aviculopecten princeps, Chonetes mucronatus* and *Chonetes coronata, Grammysia, Spirifer granulifera, Spirifer mucronatus, Tentaculites,* and *Algæ,* more particularly *Spirophyton caudagalli.*

In the *lower part* the sandstone is not so massive, being more flaggy and shaly; the flaggy sandstone at times becoming quite calcareous, and is very much stained with iron. Shale alternates with sandstone, and toward the bottom predominates, being of a gray and dark olive color, sometimes thinly laminated and fissile.

Along the Aughwick creek near Potts's Gap in the lower strata there is a fine exhibition of ripple marks.

These rocks make ridges and in the Aughwick Valley are not of economical importance; in New York the Hamilton contains a number of very fine flagstone quarries.

Marcellus (Cadent Lower) black slate.

Upper member	(Nos. 62, 61 and 60)	.....571 feet.	875′
Middle "	(No. 59)	..... 20 "	
Lower "	(Nos. 58, 57 and 56)	.....284 "	

This formation might be more properly divided into an upper and lower portion as the lithological characters of each are quite distinct; what we have called the middle member may prove to be but locally deposited.

The *upper member* consists of brown, gray, olive and black argillaceous shale with occasional seams of flaggy and slightly calcareous sandstone in the upper part, and seams of non-calcareous sandstone in the lower part. The sandstone and shale, but more particularly the latter, are very much stained with iron and bituminous matter.

The *middle member* is made up of shaly argillaceous limestones, alternating with greenish-gray lime shale. The exact position of this member of the series may be a little above or below that given in the section. The only place where it seemed possible to study this portion was in the valley of Blacklog Creek, near Orbisonia, where the dip of the strata was rather uncertain, and too far from the section line to make its position certain. Although it has been thought best to suggest only a local deposit of this limestone, economically considered, yet it seems quite certain that the horizon may not be more calcareous in one locali y than in another, but, on account of the associated strata being very argillaceous, the carbonate of lime may be more generally disseminated in one place than in another; in the former case producing nothing but a calcareo-argillaceous shale, and in the latter case an argillaceous limestone.

The *lower member* consists of black fissile slate and black and brown shale, the surfaces of both being very much stained with iron and coated with bituminous matter. In this lower member in the valley of the Juniata, above and below Lewistown, occur irregular deposits or beds of coal, the vestiges of a vegetation which appears to have been air breathing or terrestrial. The lower horizon of the series is marked by an important ore bed No. 56 which primarily is a proto-carbonate of iron but which has been changed at its outcrop by atmospheric action into a brown peroxide of iron.

It is not an infrequent thing to find the black shale and slate of the lower member very much contorted and dipping in an opposite direction to the general lay of the strata. These transverse dips are seldom of any extent and if relied upon lead to errors in constructing a section. It seems probable that some of the faults which have been located in the Marcellus and

associate strata may have been based upon observed dips in the lower member.

The epoch is valley making and has three horizons of more or less economical importance.

The *Marcellus iron ore* bed is of great importance from the Juniata River to the Maryland State line and supports a large iron industry. It varies in thickness from 3 and 4 up to 10 feet, occurring as a series of solid gray layers separated by thin seams of slate. In its native proto-carbonate condition it is a bluish-gray or lead colored ore, sometimes massive, breaking into square pieces, and at other times of a slaty or laminated structure. Where the ore has not been thoroughly subjected to atmospheric action the change to brown peroxide is only partial, a solid nucleus forming the interior of the lump, while the peroxide occurs on the surface as a crust of greater or less thickness.

The following are two partial analyses made by Mr. A. S. McCreath, Chemist of the survey, of ores from the end of Jack's Mountain:

	Fleck's bank.	McCarthy's bank.
Iron	46.5	39.100
Manganese	——	.201
Sulphur	trace	.430
Phosphorus	.133	.060
Insoluble residue	17.120	——

Upper Helderburg or Corniferous Limestone (Post Meridian).

Thickness: Three Springs and Saltillo (Nos. 55 to 47 inclusive), 60 feet.

Character: Consists of dark blue and gray argillaceous limestone alternating with green, olive and gray calcareous shale. Prof. Rogers, in the first report, says: "That the post meridian series may scarcely be called a Pennsylvania deposit as it only enters the eastern borders of the State near the Delaware Water Gap." He includes the calcareous beds which have been placed in the section as Upper Helderberg in the Marcellus Epoch; but as the limestone strata seem to be very generally distributed through the centre of the State and as they must owe their origin to dynamical conditions entirely different from those existing during the black slate deposition above, from which they differ so widely lithologically it seems more reasonable to consider the limestone as representative of the New York Upper Helderberg until the division can be established palæontologically, or on other than purely lithological grounds.

These rocks form one flank of the ridge made by the Oriskany. Some of the more massive limestone strata are quarried, the stone on being burned making a poor lean lime. In some places the formation contains a rather poor argillaceous carbonate of iron (ore bed). The Hawk Mine, worked by the Rockhill Iron and Coal Co. north of Orbisonia, is located on this bed, which appears to be a local deposit.

The petroleum of Canada, according to Prof. T. S. Hunt, is indigenous to this formation.

No. VII. *Oriskany (Meridian) Sandstone.*

At Three Springs, Nos. 45, 44 and 43.....Thickness..... 58 feet.
At Orbisonia..... " ..... 150 ± "

The *upper part* is composed of a coarse-grained ferruginous and calcareous sandstone containing a great deal of iron toward the top, and is surmounted by a bed of ochreous clay.

The *central portion* is made up of a loose, friable sandstone containing pebbles the size of a pea, larger than any found in the upper or lower parts.

The *lower part* consists of a coarse-grained, arenaceous sandstone more fragile than any toward the top of the mass, and breaking into more irregular shapes. The sandstone contains a great deal of ferruginous matter and the surfaces are at times coated with peroxide of iron.

The epoch contains the following fossils: *Cyrtoceras expansus*, *Dalmania micrurus*, *Eatonia peculiaris*, *Megambonia lamellosa*, *Orthis hipparionyx*, *Platyceras ventricosa*, *Pterinea texilis*, *Rensselæria marylandica*, *Rensselæria ovalis*, *Rensselæria ovoides*, *Spirifer arenosus* and *Spirifer arrectus*.

The species of marine life found in the lower Helderberg limestone seems to have been cut off by the changes which ushered in the Oriskany Epoch, a group of fossils peculiar to it assuming their place. Most of the fossils are remains of mollusks, no vertebrates or remains of land plants have yet been found. So far Palæontology seems to assign a distinct place to the Oriskany between the Silurian and Devonian ages. Viewing the dynamical conditions attending the deposition of the Devonian age Dr. Newberry places the Oriskany at its base; and says: "The Devonian rocks of Ohio form a circle of deposits, which records an invasion of the land by the sea, and presents in its series of strata, a history of the successive stages of that invasion; first, the mechanical sediment of the Oriskany; then the Corniferous limestone, the deposit of the open sea; then mixed mechanical and organic materials; the mechanical sediments finally predominating and indicating a return to land conditions over all the eastern portion of the continent."

The epoch is ridge making, and has three horizons of economical importance:

1st. Upper ore bed, occurring at the upper limit of the sandstone. This bed is seldom workable in Pennsylvania, but is very productive in the valley of the James river, Virginia. In many localities the mass consists merely of the upper strata of the sandstone strongly impregnated with peroxide of iron.

2d. In the Juniata Valley where the Oriskany is friable and contains little or no iron, it affords a valuable sand for glass manufacture.

3d. Lower ore bed, occurring at the junction of the coarser and more arenaceous strata at the bottom of the sandstone with the soft, calcareous yellow layers beneath it. This bed is worked by the Rockhill Iron and Coal Company near Orbisonia and in Hill Valley.

No. VI. *Lewistown (Pre-meridian—Lower Helderberg,) Limestone.*

Thickness: (Nos. 42 to 38 inclusive) 162 feet.

Character: Consists of massive, dark blue and gray, semi-crystalline limestone, containing toward the upper and lower parts alternating layers of gray shaly limestone and argillaceous lime shale. To the north-east in the Juniata Valley from Mount Union to Lewistown, the shale at the top of the mass becomes a thicker and more distinctive formation. There are fine exposures of the series along the Kisicoquillas creek, near Lewistown, Mifflin County, where it was found necessary to give it a new geographical name in the failure to identify it with any of the sub-divisions of the lower Helderberg group in New York.

The following fossils have been determined: *Acervularia, Alveolites minima, Astylospongia inornata, Merista lævis, Orthis oblata, Pentamerus galeatus, Rhynchonella formosa, Astylospongia, Atrypa reticularis, Aulopora, Conophyllum, Merista arcuata, Stromatopora, Trematospira formosa,* and *Zaphrentis.*

This formation with the Oriskany is ridge making, and of great economical importance, as it furnishes good lime for building and agricultural purposes, besides being an excellent flux in the iron furnace. A specimen from Saltillo contained: Carbonate of lime 90.904; carbonate of magnesia 2.162.

An iron ore having a laminated structure occurs sometimes scattered in the soil overlying the limestone.

Water-lime (Scalent) Cement Beds.

Thickness: (Nos. 37 to 28 inclusive) 580 feet.

Character: Consists for the most part of a blue and gray flaggy and thinly bedded limestone having a wavy stratification. Toward the top the limestone is massive, slightly argillaceous and of a dark gray and bluish-gray color; but toward the bottom it becomes flaggy, thinly laminated and shaly, having a brownish-gray and yellow color. In the lower part limestone alternates with green, yellow and gray argillaceous shale.

The strata in the central part contain a great deal of calcite, and the surfaces of the stone are oftentimes coated with carbonaceous matter, and show "slickensides." The limestone beds are frequently highly magnesian, and a few may be compared economically with the Lewistown limestone. The outcrops occupy a small valley at the foot of the Oriskany ridge

Onondaga (Scalent) Marls.

		Saltillo and Three Springs.	Orbisonia.
Thickness:	Upper member Nos. 27, 26 and 25.....	170 ± feet.	145 feet.
"	Lower " " 24, 23 " 22.....	270 ± "	230 "

The upper member consists of yellow, gray and greenish shaly and argillaceous (fossiliferous) limestone in thin beds, alternating with olive, green and gray calcareous shale.

The lower member consists of green, yellow and gray calcareous shale,

alternating with red shale and containing occasional beds of fossiliferous, shaly limestone.

The Salina group thins in this district to the south-east, being thicker on the Jacks Mountain range than it is along Blacklog Mountain. It makes a valley and is of no economical value.

Niagara Limestone.

The Niagara limestone seems to be without a representative in Pennsylvania.

In a section which was constructed through Jacks Mountain at Mount Union, a limestone bed 3 feet thick was located 232 feet above the top of the Clinton red shale, which was supposed to be the representative of the Niagara limestone; the intervening space between this and the Clinton being filled with a soft, argillaceous, calcareous shale. The occurrence of the Niagara limestone here, as well as at Logan Gap 25 miles to the north-east, where a similar bed 4 feet thick was found, is extremely doubtful. A careful search for its representative at Rockhill Gap in Blacklog Mountain, and on each side of the Jacks Mountain anticlinal at Three Springs, and Saltillo, failed to bring it to light. It is questionable in the author's mind whether the Niagara measures which form such a marked feature in the geology of northern New York has in this section of Pennsylvania a distinct representative. While this epoch seems to be vacant in our palæozoic column, the Salina rocks, which occur directly above the Niagara, seem to be totally different in character from the New York strata, where they are composed of shales, marls and marly sandstones with impure limestone; ours being almost entirely destitute of fossils. Is it not possible that the strata which are included between the bottom of the Water lime shale and the top of the Clinton red shale represent equally or conjointly the Salina and Niagara groups of New York?

No. V. *Clinton* (*Surgent*) *Shales.*

		Saltillo.	Orbisonia.
1. Red shale (Nos. 21, 20 and 19).....	Thickness	270 feet.	233 feet.
2. Upper olive shale (Nos. 18 to 15 inclusive)	"	162 "	163 "
3. Ore sandstone and fossil ore (Nos. 14 to 11)	"	42 "	54 ± "
4. Lower olive shale (Nos. 10 and 9).....	"	— "	660 "

1. The upper part of the red shale consists of silicious massive red shale having a rhombohedral fracture. Toward the lower part the red shale becomes more argillaceous and contains thin alternations of gray and green calcareous shale, while at the bottom there are beds of red shaly sandstone having seams of calcite running through the mass.

2. The Upper olive shale consists of yellow, olive and gray calcareous shale containing seams of blue fossiliferous limestone; the lower part forming the hanging wall of the fossil ore beds is composed of a light yellow argillaceous lime shale.

3. The fossil iron ore beds occurring above the ore sandstone have been extensively developed in Rockhill Gap by the Rockhill Iron and Coal Co.

Beside seams Nos. 12 and 14 of the section there are two other small beds below the ore sandstone. The first, from 4 to 6 inches thick, occurs directly under the sandstone and about 50 feet below the upper beds (C. Constable). The second is 10 inches thick and about 4 feet below the first. These two beds have never been worked. The beds above the sandstone are worked on the south side of Rockhill Gap by two drifts 100 feet vertically apart and having an average course of S. 21° W. The same beds are worked also on the north side of the Gap by two drifts which are about 60 feet vertically apart, the strike being about the same as on the south side. The course of the south drifts when continued across the Gap to the north side strikes about 100 feet to the west of the north openings, the ore range being thrown to the east on the north side by a fault which runs through the Gap at right angles to the strike. In gangway No. 1 on the south side the yield of a specimen was as follows :

	No. 14.	No. 12.
Iron	50.800 per cent.	50.700
Sulphur	trace.	trace.
Phosphorus	.112	.123

The ore sandstone has a thickness of 42 feet at Saltillo and of 50 feet at Orbisonia.

The sandstone varies very much in character in the different localities, as to the amount of calcareous matter which it contains ; at Rockhill Gap it is very silicious, while at Saltillo it is quite calcareous. In the latter locality the ore beds seem to be represented by a calcareous sandstone containing a large percentage of iron, but not a true iron ore.

The sandstone generally forms a terrace along the flank of the mountain of No. IV.

4. Lower olive shale (Nos. 9 and 10).—Thickness : 660 feet.—For description see section

The following fossils were found in the Clinton Epoch, more particularly in the upper olive shale : *Atrypa reticularis, Beyrichia lata, Buthotrephis gracilis, Dalmania limulurus, Homalonotus delphinocephalus, Orthis elegantula, Platyostoma niagarensis, Pterinea emacerata, Rhynchonella neglecta* and *Strophomena rhomboidalis.*

No. IV. *Medina (Levant) Sandstone,*

White sandstone, No. 8.....Thickness 400 feet.
Red sandstone and shale, No. 7..... " 930 " } 1330′

The white sandstone contains in New York several characteristic fossils, some of which the marine plants, and more particularly the *Arthrophycus harlani,* are found throughout its whole range from Pennsylvania to the south border of Tennessee.

The red sandstone and shale member is in Pennsylvania entirely destitute of fossils, and is a coarser and more sandy rock, than in New York, where it is composed principally of a finely-comminuted red marl or a calcareous red clay, containing a few organic remains.

A deposit of iron ore exists in the white Medina forming the crest of Blacklog mountain 4 miles south-west of Orbisonia. The ore and clay in which it lies seem to fill a transverse fissure or cleft in the white sandstone, at a point where there is a slight indentation in the crest of the mountain.

Oneida (Levant) Sandstone.

Upper member, red and greenish-gray silicious breccia and conglomerate, No. 6, thickness 158 feet.....	568′
Lower member, hard massive, greenish gray sandstone and conglomerate, No. 5, thickness 410 feet.....	

A striking feature of the epoch is its poverty in organic remains.

The Medina and Oneida rocks taken together make "all the mountain ridges and higher spurs of the entire chain west of the Susquehanna, between the Kittaning valley and the valley at the base of the Alleghany mountain," except those surrounding the Broad Top synclinal basin.

No. III. *Hudson River (Matinal) shale.*

Thickness: (No. 4) 800 feet.

Utica (Matinal) slate.

Thickness: (No. 3) 1070 feet.

The upper limit of No. III is well defined by the rapid and sudden transition of the Oneida gray sandstone and conglomerate into the argillaceous sandstone at the top of the Hudson River slates. The lower limit has been assumed at a very lean, poor shaly brown hematite ore, which seems to occur at the horizon between the shale and slate of the Utica and the blue calcareous shale at the top of the Trenton or Matinal limestone mass. The division between the Hudson and Utica was not positively determined, and may possibly be above or below the position which has been given it. Unconformability has been asserted to exist between the Hudson and Oneida.

Prof. Rogers speaks of it as follows: "The relations of the Matinal series to the overlying Levant strata * * * plainly show that * * * the earth's crust experienced a prodigious movement at the close of the Hudson period. This agitation of the floor of the sea, which had just received the materials of the Hudson shales, appears to have been everywhere attended by an extensive displacement of its level, accompanied in some districts by undulations amounting even to a close plication or corrugation of its sediment, and in some districts to a lifting up of wide areas above the general sea level into dry land."

The slates of No. III make one flank of the mountain of No. IV, and contain no strata of economical value in this district.

No. II. *Trenton (Matinal) limestone.*

Thickness: (No. 2) 500 ± feet.

The thickness of the epoch is only approximately determined from a

very limited observation in Blacklog valley. A very distinct palæontological break exists between this epoch and the underlying auroral magnesian limestone, the upper strata of which are exposed in the centre of Blacklog Valley opposite Rockhill Gap. It is probable that the Magnesian rocks in this part of Pennsylvania are at least 3000 feet thick, which would place the top of the Potsdam sandstone (the lowest group in the Palæozoic column), at least three quarters of a mile vertically beneath the present surface of the centre of Blacklog Valley.

LOCALITIES WHERE THE STRATA WERE MEASURED AND STUDIED.

No. XIII.

Nos. 267, 266, 260, 256 and 252. Robertsdale, Trough Creek coal basin, Carbon Township.

Nos. 265 to 261 inclusive. Coal bed D (Lower Freeport ?) Section measured about 400′ from mouth of mine C¹, Robertsdale collieries.

Since the section was compiled, I have been informed by Mr. Wm. A. Ingham, President Rockhill Iron and Coal Co., that a bed of black band ore has been discovered in the "Swamps" in mine C′, between the bottom bench of coal and the fireclay floor, ranging from 1 to 4 inches thick and yielding 30.79 per cent. of metallic iron.

Nos. 259, 258 and 257. Coal bed C (Kittanning ?) Section measured about 200′ from mouth of mine B¹, Robertsdale collieries.

Nos. 255, 254 and 253. Coal bed B (Clarion ?) Section measured by Wm. Foster, Esq. in mine A, Robertsdale collieries.

No. 251. Coal bed A (Brookville?) Section reported by Wm. Foster, Esq. "Monkey drift," Robertsdale collieries.

No. XII.

No. 250 to 244 inclusive. Rocky Ridge near Wray's Hill Tunnel, Todd Township and Wray's Hill, Carbon Township.

No. XI.

Nos. 243, 242, 241 and 240. Wray's Hill and Rocky Ridge.

No. 239 to 234 inclusive. Wray's Hill Tunnel E. B. T. R. R.

Nos. 233 and 232. Ground Hog and Plank Cabin Valleys, Carbon Township.

Nos. 231 and 230. New Grenada, Taylor Township, Fulton County.

No. 229 to 220 inclusive. Limestone quarry worked by John Whitney, Esq., near Todd P. O., Plank Cabin Valley.

No. 219. Ground Hog and Plank Cabin Valleys.

No. 218 to 213 inclusive. Well on Ezra Heater's farm, one mile south of Todd P. O., section reported by Mr. Chas. E. Billin.

No. X.

No. 212. Ground Hog and Plank Cabin Valleys.

No 211 to 124 inclusive. Sideling Hill Tunnel E. B. T. R. R.

No. 123 to 117 inclusive. Smith's Valley. Clay, Cass and Union Townships.

The total thickness of No. X was verified by measurements made in Sideling Hill Gap, Fulton County.

No. IX.

Nos. 116, 115, and 114, Smith's Valley.

No. 113, J. B. Moreland's farm, Smith's Valley near Sideling Hill Tunnel.

No. 112 to 108 inclusive. Smith's Valley, along line of E. B. T. R. R. and Sideling Hill Creek. Deposits of "drift coal" in No. 109 found on Wm. Smith's farm, 1½ miles from Mapleton, Union Township.

No. 107 to 96 inclusive. Transition strata. R. R. cut end of Clear Ridge, north-west of Saltillo, Clay Township.

No. VIII.

No. 95 to 85 inclusive. Line of E. B. T. R. R., north-west of Saltillo and Sideling Hill Creek, Clay Township, and Coaling Ridge, Cromwell Township.

No. 84 to 71 inclusive. Line of E. B. T. R. R., north-west of Saltillo, and north-east of Three Springs, Clay, Springfield and Cromwell Townships.

No. 70 to 67 inclusive. Sideling Hill Creek and line of E. B. T. R. R. north-west of Saltillo, Clay Township and north-east of Three Springs, Springfield and Cromwell Townships.

No. 66 to 63 inclusive. North-west of Saltillo, Clay Township and Saddleback Ridge, Springfield and Cromwell Townships.

Nos. 62, 61, 60, 58, 57, and 56. North-west of Saltillo, north-east of Three Springs and Aughwick Valley near Orbisonia.

No. 59. Quarry near I. Engeart's house, 1 mile from Orbisonia.

No. 55 to 47 inclusive. R. R. cut at Three Springs.

No. VII.

Nos. 45, 44 and 43, R. R. cut at Three Springs. Fossils were found on end of Royer and Sandy Ridges near Orbisonia.

No. VI.

No. 42 to 38 inclusive. Near Three Springs, Saltillo and Orbisonia; fossils found at latter locality.

Nos. 37, 36 and from 34 to 28 inclusive. Near Saltillo. Three Springs and Orbisonia.

No. 35, Rockhill Furnace water-lime quarry near Orbisonia.

No. 27 to 22 inclusive. Near Saltillo and Three Springs.

No. V.

Nos. 21, 20 and 19. Near Saltillo and Three Springs.

No. 18 to 15 inclusive. Near Saltillo and in Rockhill Gap, Cromwell Township. Fossils found at Rockhill Gap.

Nos. 14, 13 and 12. South fossil ore mine, Rockhill Gap.

No. 11, Rockill Gap and opposite Leas and McVitty's tannery at Saltillo.

No. 10 and 9, Rockhill Gap.

No. IV and III.

No. 8 to 3 inclusive. Rockhill Gap.

No. II.

No. 2 and 1, Blacklog Valley, Cromwell Township.